



**DIRECTED ENERGY, INC.**

**PDG-2515/2520**

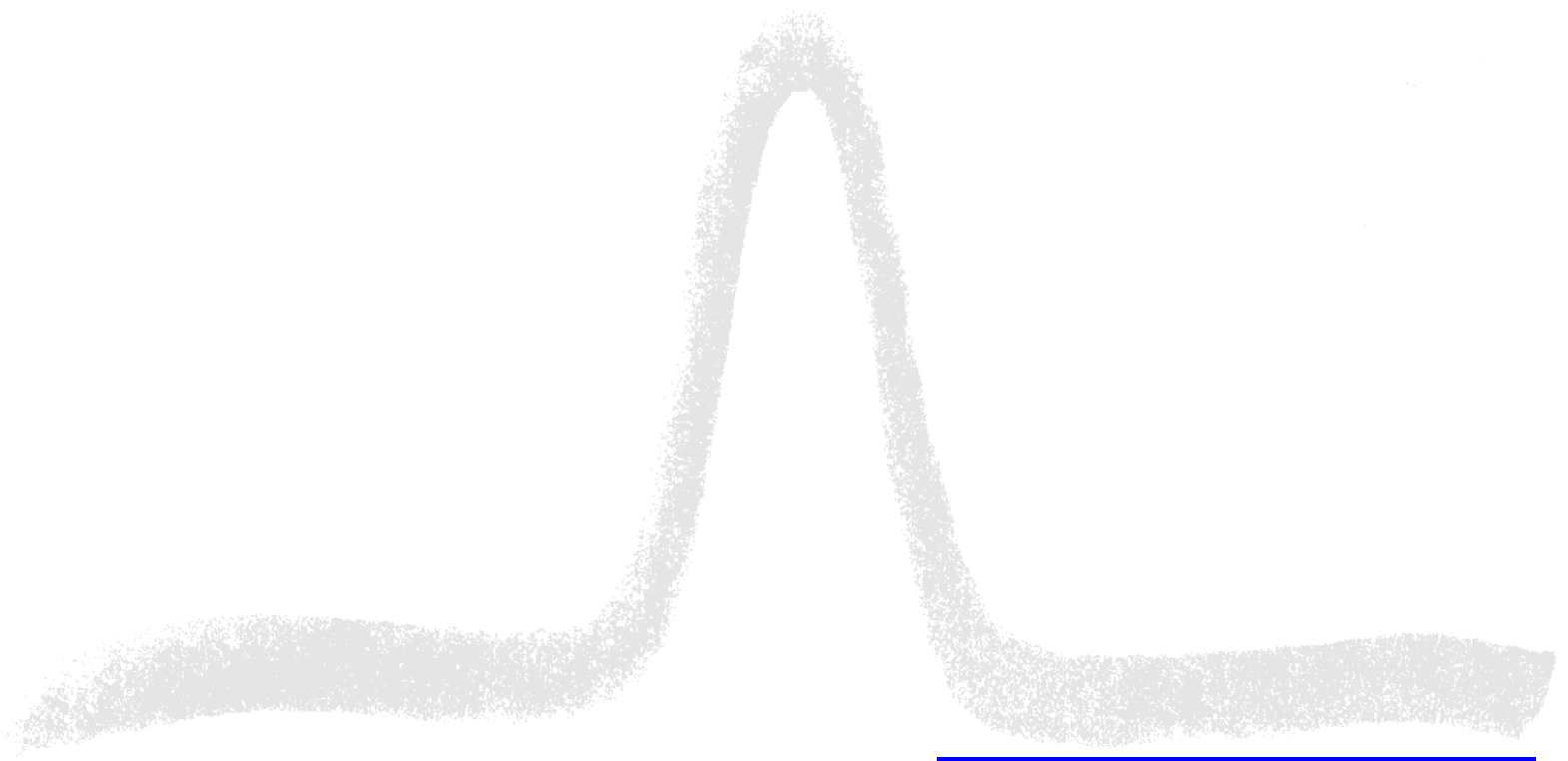
**Digital Delay and Pulse Generator  
OPERATING MANUAL**



[www.directedenergy.com](http://www.directedenergy.com)



**THE PULSE OF THE FUTURE**



***THE PULSE OF THE FUTURE***

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## **Safety Warning**

### **SAFE OPERATING PROCEDURES AND PROPER USE OF THE EQUIPMENT ARE THE RESPONSIBILITY OF THE USER OF THIS SYSTEM.**

Directed Energy, Inc. (DEI) provides information on its products and associated hazards, but it assumes no responsibility for the after sale operation and safety practices.

Users are responsible for reading and understanding all safety precautions listed in this manual prior to operation of the equipment. There are no user serviceable parts in this product, please contact the factory for service information.

## PDG-2515 Operating Manual

### Quick Start Guide

This quick-start guide provides a step-by-step guide to manually operating the PDG-2515. Please refer to the appropriate sections of the manual for additional instructions and guidelines. The SAFETY warnings in the manual must be read and understood prior to operating the PDG-2515.

#### ***What's In The Box?***

- 1ea. PDG-2515 Digital Delay & Pulse Generator
- 1ea. Power Cord
- 2ea. 50 Ohm Coaxial Output Cable
- 1ea. Operating Manual

#### ***Unpacking***

Carefully remove each component listed above. Your PDG-2515 and accessories were inspected at the factory prior to shipment. Inspect the PDG-2515, power cord and output cables for signs of shipping damage. If any damage is noted contact the factory prior to operating the equipment.

#### ***Setup***

Connect *OUT1* and/or *OUT2* to an appropriate load using 50 Ohm coaxial cable (included).

Plug the AC power cord into the rear power entry module of the PDG-2515, and into an appropriate AC socket.

#### ***Power Up***

Turn on the PDG-2515 by pressing the **power** button located above the power entry module in the rear of the unit.

The front panel display will read initialize and display the software and hardware versions internal to the unit on the front panel. After a few moments the unit will finish initialization and the first screen/menu that will appear is the menu for CHANNEL 1. Note: The buttons and encoder on the front panel will have no effect as the unit comes up from initialization.

### ***Front Panel Controls & Connections***

#### **Encoder**

This is for varying the parameters such as Frequency, Pulse Width, Delay, Trigger Source, etc.



**Output Button**

The output button enables/disables the pulse output.

**Menu Button**

This button is for navigating the PDG-2515 menus.

**Enter Button**

Used for variables that will be permanently stored in the unit or require setup times internal to the PDG-2515. When a question mark appears after the variable, the enter button will “confirm” or in some cases save that particular setting.

**Up Arrow Button**

The UP ARROW button allows the user to go up in any particular menu to change selections. If the user is at the top selection it will wrap back around to the bottom selection.

**Down Arrow Button**

The DOWN ARROW button allows the user to go down in any particular menu to change selections. If the user is at the bottom selection it will wrap back around to the top selection.

**X10 Button**

The X10 button is used when varying parameters that have exponents that can change by a power of 10. By pressing the X10 button the user can increment the exponent within its acceptable range. This allows the user to quickly set the parameters, without having to excessively scroll the encoder wheel. The X10 button functions with the following commands:

Set Pulse Width 1 and 2

Set Delay 1 and 2

Set Frequency (\*Note: if depressed while dialing in frequency it will increase the frequency at a much higher rate)

Set Counters/Bursts/Packets

The X10 button is effectively a 10X multiplier. For example, when setting frequency, the resolution of the encoder wheel is three digits (i.e. 1.00Hz, 10.0Hz, 100Hz, 1.00KHz). Therefore without adjusting the range, the encoder wheel must be turned many times to increase the frequency from 1Hz to 100Hz. However if the frequency is set to 1.00Hz, if the X10 button is pressed once, it changes to 10.0Hz. If it is pressed twice, it changes to 100Hz.

Setting the delay and pulse width is similar to setting frequency. For example, to set the delay to 300ns, set the delay to 25ns, press the

X10 button once to increment it to 250ns, then rotate the encoder wheel to increase it to 300ns. At this point, pressing the X10 button again would increase the delay to 3.00us, pressing it again increments it to 30.0us, etc.

An additional function is that if it is held while changing ANY frequency value, after multiplying the value by a factor of ten, if the encoder is moved it will increase/decrease at a much faster rate. This makes the switching frequency much quicker and easier.

### **PW/PRF Button**

This is for varying the parameters Frequency and Pulse Width and toggling between the two settings quickly. If you are in any menu that is not a CHANNEL MENU, it will flip you immediately to the CHANNEL 1 menu and the FREQUENCY setting.

### **Out 1 and Out 2**

These are the pulse output connectors. The outputs of the PDG-2515 should be connected to the inputs of the receiving instrument or system using 50 Ohm coaxial cable. For optimal pulse fidelity, these outputs should be terminated into 50 Ohms.

### **Sync Out**

This is a 5V signal into 1 meg-Ohm or 2.5V signal into 50 Ohms that is synchronous with the frequency generator trigger. This is designed to assist the user in triggering when monitoring the output signals with an oscilloscope, or for use in triggering an external instrument.

### **Trigger In**

This is an input signal into 1KOhms used for external Pulse Repetition Frequency (PRF) triggering. It is designed to allow the user to trigger multiple PDG-2515 units from a single pulse generator. This allows the user to create synchronous waveforms from multiple units.

### **Power LED**

Indicates that the power switch on the rear of the unit is in the 'on' position and that AC power is applied to the unit.

## ***Front Panel Controls & Connections***

### **AC Power Entry Module**

The driver is grounded through the grounding conductor of the AC power cord. To avoid electrical shock, plug the driver into a properly wired receptacle before making connection to any input or output connectors. Use only a power cord that is in good condition.

The PDG-2515 accepts input voltages of 90-264VAC, 47-63Hz.

### ***Example Setup***

The default setup is 1 kHz, with zero delay and 100 us pulse on both channels. The pulse is not inverted and the pulse mode is in continuous pulse generation mode which means that pulse count is not available. By pressing the **OUTPUT** button on the front panel you will see these pulses on the respective outputs.

Turning the encoder with the pulses enabled and the unit will sweep the frequency on the fly, hitting the **X10** button will bring you to 10 times the frequency. Pressing the down arrow twice will highlight the pulse width selection. Turn the encoder and the width will sweep. Try this with the polarity setting; it will change on the fly. Turn off the pulses.

Press **MENU** to continue to the settings for CHANNEL 2. Its default is the same as CHANNEL 1.

Hitting **MENU** again will bring up the OUTPUT MENU. This menu allows the unit to change pulse modes, disable and enable the outputs (depending on the pulse mode), choose internal or external trigger (depending on the pulse mode) and choose whether the sync is based off CHANNEL 1 or 2.

Hitting the arrow keys allows the user to decide which settings on the current menu they would like to adjust. Press the up arrow once to scroll around to the bottom of the menu or press the down arrow 5 times. The contrast setting will be highlighted.

Turn the encoder to adjust the contrast. The contrast will adjust “on the fly” and a question mark will appear at the end of the contrast. Hit ENTER and save the contrast saving into the non-volatile memory of the unit, this setting will be saved into the unit and keep this in memory even after power-down.

## Product Overview

### *Description*

The PDG-2515 is a two channel digital delay/pulse generator. Each channel offers independently adjustable delay and width, with 25 nanosecond resolution. Up to five user configurations may be stored in internal non-volatile memory, and recalled through the easy to understand front panel.

### *Functions & Features*

<b>Delay And Width and Duty Cycle.</b>	Each channel provides independently adjustable delay and width, with 25ns resolution. The duty cycle is limited based on the frequency. The duty cycle is limited approximately by the equation: $MAX\ DC = 97 - [(1E-5) * FREQ]$ .
<b>Frequency</b>	Pulse repetition frequency from single shot to continuous pulses from 100 mHz to 3.0 MHz.
<b>Resolution</b>	100mHz to 1.0 MHz -> 3 digits 1.0 MHz + -> 2 digits
<b>Trigger Sources</b>	Internal, External, Single Shot.
<b>Pulse Generator Mode</b>	Generates pulses at the rate set by the internal frequency generator, or by an external trigger.
<b>Pulse Count Mode</b>	Outputs pulses at the rate set by the internal frequency generator or external trigger and stops after N pulses.
<b>Divide By N Mode</b>	Channel 1 operates in continuous mode, channel 2 pulses every Nth pulse on channel 1.
<b>Burst Mode</b>	Generates a burst of pulses, repeating at a frequency.
<b>Counted Burst Mode</b>	Generates a burst of pulses, and stops after N bursts.
<b>Store And Recall</b>	Stores up to 5 user configurations in non-volatile memory.

## Specifications

PARAMETER	Value
<b>OUTPUTS</b>	
Output Channels	Two (2) outputs, each with independent digitally controlled delay and pulse width
Delay Range	0 to 99.9 Seconds
Pulse Width Range	25 Nanoseconds to 99.9 Seconds
Delay And Pulse Width Resolution	25 Nanoseconds below 1 Microsecond 50 Nanoseconds from 1 Microsecond to 10 Microseconds 3 Digits Above 10 Microseconds
Accuracy (Delay and Pulse Width)	±2%
Time Base	120MHz Frequency Synthesizer
Delay Jitter (1 <sup>st</sup> Sigma)	TBD
Trigger Delay (External Trigger to SYNC (T <sub>0</sub> ) Output)	75 Nanoseconds
Internal Throughput Delay (SYNC (T <sub>0</sub> ) To Output 1 Or Output 2 Rising Edge)	<25 Nanoseconds
Output Rise & Fall Times (Into 50Ω)	<5 Nanoseconds
Over/undershoot	<5%
Amplitude	+4V into 50W
Output Connectors	BNC, Front Panel
<b>INTERNAL RATE GENERATOR</b>	
Modes	Continuous, Single-Shot, Burst, External Trigger, Divide By N, Pulse Count
Rate	Single-Shot or 100 millihertz to 3MHz (Internal) Single-Shot to 5MHz (External Trigger)
Resolution	3 Digits (<1MHz), 2 Digits (>1MHz)
Accuracy (Continuous, Pulse Count, Output-2 Modes)	25 PPM
Accuracy (Burst Mode)	±2%
Rate Jitter (Continuous, Pulse Count, Output-2 Modes), 1 <sup>st</sup> Sigma	TBD
Rate Jitter (Burst Mode), 1 <sup>st</sup> Sigma	TBD
Burst and Pulse Count Mode	2 to 65,535 Pulses per Burst or Count
<b>EXTERNAL TRIGGER INPUT</b>	
Type	Positive Edge Trigger
Input Amplitude	TTL into 1KΩ
Input Impedance	1KΩ
Minimum Trigger Pulse Width	25ns
Input Trigger Connector	BNC, Front Panel
<b>T<sub>0</sub> (SYNC) OUTPUT</b>	
T <sub>0</sub> (Sync) Output	TTL output into 1 MegΩ, 4.5V into 50Ω
Connector	BNC, Front Panel
<b>COMPUTER INTERFACE</b>	
Interface Type	N/A
Interface Connector	N/A
<b>GENERAL</b>	
Internal Non-Volatile Storage	5 Configurations
Operating Temperature Range	0°C to +40°C
Cooling Requirements	Air cooled
Input AC Power	90-264VAC, 47-63Hz, 28W Maximum
Dimensions (H X W X D)	3 ½" H x 8" W x 6 1/4" D (8.9cm H x 20.3cm W x 15.9cm D)
Weight	2 lbs. (.9kg) Approximate

## ***Applications***

The versatile functionality of the PDG-2515 makes it ideal for the needs of numerous applications as a small bench top instrument. The delay resolution and width resolution of each channel allow a unique ability to offset control signals, coupled with ability to logically manipulate the outputs together to form gate signals or specific waveforms make automation of testing and control an easier process.

## **Safety**

Normal use of test equipment exposes the user to a certain amount of danger from electrical shock because testing may be performed with exposed voltages present, dictating the use of caution when operating or servicing this equipment. The following is a summary of general safety precautions that must be observed during all phases of operation and repair of the PDG-2515.

### ***Operating Safety Summary***

The safety information contained in this summary is for both operating and servicing personnel. Specific warnings may be found throughout this manual, but may not appear in this summary.

#### **Power Source**

The PDG-2515 is designed to operate from a regulated power source. To assure proper system operation the input voltage should not vary by more than 10% from the recommended specification. The PDG-2515 accepts input voltages from 90VAC to 264VAC at 47Hz to 63Hz.

A protective grounding connection by way of the grounding conductor in the AC power cord is essential.

#### **Grounding**

The PDG-2515 is grounded through the grounding conductor of the AC power cord. **To avoid electrical shock, plug the PDG-2515 into a properly wired receptacle before making connection to any input or output connectors.** Use only a power cord that is in good condition.

#### **Cover Removal**

To avoid personal injury, do not remove the covers. **Do not operate the PDG-2515 while the covers are removed.** Operating the unit with the top cover removed voids any and all warranties associated with the PDG-2515.

#### **General Operating Precautions**

Do not open the unit while the system is in operation. Use caution when handling or removing the output cables while the unit is operating. Turn off

equipment when making connections in high voltage or high current circuits. Discharge high voltage capacitors after removing power.

### ***Servicing Safety Summary***

DEI strongly recommends that all repairs and adjustments be performed by factory qualified personnel. DEI will not be responsible for personal injury or damage to the pulse generator that occurs during repair by any party other than the factory. Any repairs, adjustments or modifications made by anyone other than authorized DEI personnel voids the factory warranty.

### ***PREPARATION FOR USE***

#### **General**

After unpacking, initial inspection and electrical installation procedures should be performed to assure that the unit is in good working order. If it is determined that the unit is damaged, the carrier should be notified immediately. Repair problems should be directed to the service department,

Directed Energy, Inc. (DEI),  
 Fort Collins, Colorado.  
 Telephone: (970) 493-1901  
 FAX: (970) 493-1903  
 EMAIL: deiinfo@directedenergy.com

#### **Initial Inspection**

- Inspect unit for exterior mechanical damage.
- Inspect power input cord and input power module for obvious signs of damage.

#### **Electrical Installation**

Standard units are shipped ready for use with a nominal 90 - 264 VAC input.

### **Operation**

This section provides basic operating instructions for the PDG-2515 hardware.

#### ***Operating Tips***

1. The two output channels have synchronized frequencies. Pulse width and pulse delay settings of one channel are dependent on the frequency of the other channel. When changing frequency be aware that both pulse width and delay are within range on both channels.
2. When using the 10X button to increase the rate at which the frequency changes, when it is first depressed the value will change by 10X, further

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change is accomplished by using the encoder while holding the 10X button down.

### **Power-Up Procedures**

The unit should be powered up using the following procedures:

Connect *OUT 1* and/or *OUT 2* to an appropriate load using 50 Ohm coaxial cable (See Section 6.0).

Plug the AC power cord into the PDG-2515, and into an appropriate AC socket.

Turn on the PDG-2515 by pressing the **power** button on the rear of the unit located above the power entry .

Configure the unit from the front panel. See the quick-start guide in Section 1.0 of this manual for specific operating instructions, and Sections 8 and 9 for detailed operation instructions.

## **FRONT PANEL OPERATING INSTRUCTIONS**

### **THE CHANNEL MENU**

The CHANNEL MENU will display which channel menu the unit is in on the top of the display. Changing the settings is done by simply rotating the encoder or pressing the **X10** button. When the setting has reached it's maximum value on the encoder it will stop increasing the value as the encoder turns. The X10 button on the other hand will set the value to the nearest minimum exponent value when the maximum value has been reached (example: 500 kHz will go to 500 mHz). This maximum value is set by the internal limitations of the unit and also the pulse settings (ie: pulse delay and duty cycle). In order the change which setting to adjust the up and down arrows will highlight the current setting. In the CHANNEL MENU all settings can be done while the unit is enabled, all settings can "sweep". Changing the pulse width and delay settings while enabled will not effect the pulse, the change will take place on the next available clock cycle internally. The frequency needs to be stopped and adjusted and then turned back on internally. This means that there could be some delay while sweeping frequency before the next frequency takes hold, this is more noticeable as the frequency is near to slower limits while the unit syncs up again to the internal oscillator. The polarity sweep will take hold immediately, as will the disable and enable functions. The polarity function will flip the polarity of the output. Pulse count will only be available in pulse count and burst modes.

### **THE OUTPUT MENU**

The OUTPUT MENU is where the unit can change its mode, disable a channel, change the trigger, change the base of the sync, and also adjust



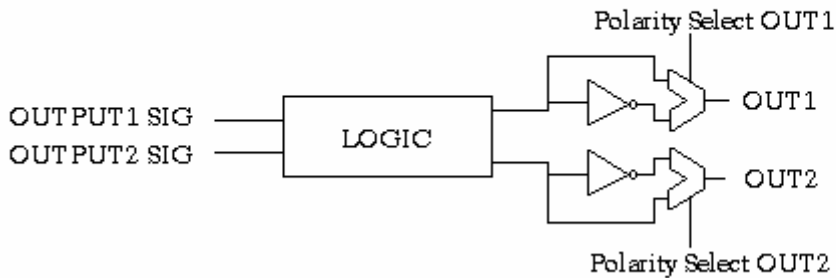
the contrast settings of the unit. The operating modes will be discussed in more detail in section 9.0. Enabling and disabling a channel can also happen on the fly in pulse generation and Divide By N modes. In pulse count mode this needs to be set before hand so the unit does not sit in an unknown state if it has not finished it's count set, therefore, the unit will not allow it to be changed while pulsing. In Burst mode, disabling the channel is not available and both are enabled. When the mode is switched from Burst mode, the enable/disable settings will return to where they were previous to Burst mode. The trigger can be set to internal or external in pulse generation and pulse count modes. Note that the unit will "lock up" until it has finished it's pulse count in external mode so the external triggering device must give it AT LEAST as many pulses as is entered. If this does not occur, the device can be "released" by switching modes. The sync can also be run off channel 1 or channel 2. This is especially useful in Divide By N mode and pulse count mode. Not that in Burst mode, the sync is a packet period limited by at most 95% duty cycle regardless of this setting.

The contrast setting can also be changed in this menu. If the contrast is adjusted by using the encoder knob or using the x10 button, a '?' will appear at the end of the setting. This means that while the unit is powered this is the setting that the unit will retain but when powered down and powered up again the unit will revert to the last saved contrast. By depressing the ENTER button the contrast will be saved in non-volatile memory and the unit will come up under this contrast setting. The contrast is has numerous settings, and a coarse and a fine adjust. The letter is a course adjustment and the number is the fine adjust. The course adjust is manipulated with the x10 button and the fine adjust is set by the encoder knob.

### **THE LOGIC MENU**

The LOGIC MENU allows the user to logically AND or OR outputs OUT1 and OUT2. LOGIC1 will output on the OUT1 channel (note: the invert function will invert the channel AFTER the logic has been applied – this is shown in the LOGIC AND POLARITY FUNCTIONAL DIAGRAM below). LOGIC2 will output on the OUT2 channel.

LOGIC AND POLARITY  
FUNCTIONAL DIAGRAM.



**Figure 1 Logic & Polarity Functional Diagram**

### **THE CONFIGS MENU**

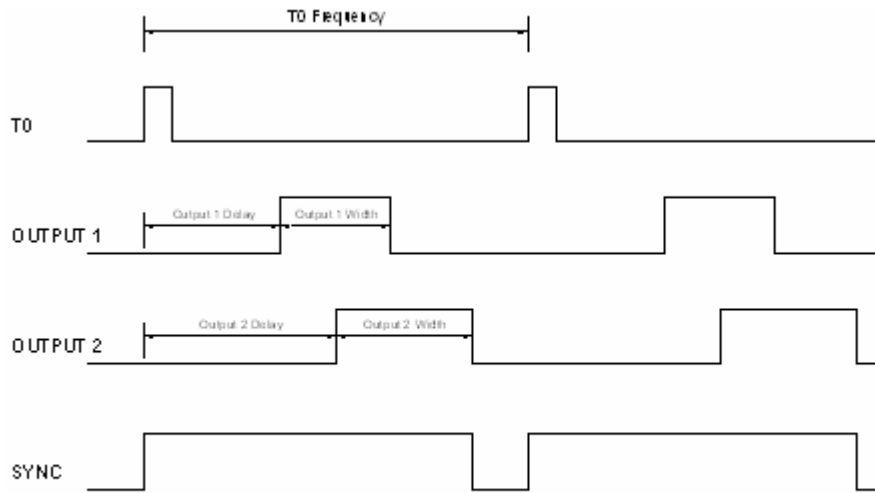
The CONFIGS MENU allows the user to save or load up to 5 different configurations. After selecting the appropriate configuration to either load or save (1 through 5) hit the ENTER button and the configuration of the unit will be saved. If the user tries to load a configuration that has not been saved yet, the unit will send an error message of "Not Valid Config" and nothing will be loaded. If the load or save is successful the active configuration (ACTIVE CON: X) will reflect this with the correct setting.

\*Note: if any values are changed, the active configuration will no longer be valid and will reflect either -- or a '0'.

### ***Operating Modes***

#### **Timing Diagram**

The timing diagram below defines the frequency, delay and width variables, and their temporal relationship to the T<sub>0</sub> frequency generator signal.



\*SYNC based on OUT 2 in unit

**Figure 2 Timing Diagram**

Please note that in external trigger mode, all outputs are delayed from the leading edge of the external trigger signal.

**Pulse Generator Mode**

In Pulse Generator Mode, the PDG-2515 generates pulses at the specified frequency denoted in the CHANNEL MENU (changing the frequency on either channel will change the frequency on both channels simultaneously – the frequencies are not independent in this mode). If externally triggered, the rate is set by the external trigger (i.e. one pulse is output each time a rising edge occurs on the TRIGGER input).

The delay of each of the outputs is relative to the leading edge of the SYNC output in internal frequency generator and single shot modes. In external trigger mode, the delay is relative to the leading edge of the external trigger input.

The pulse width and delay for each channel are independently variable.

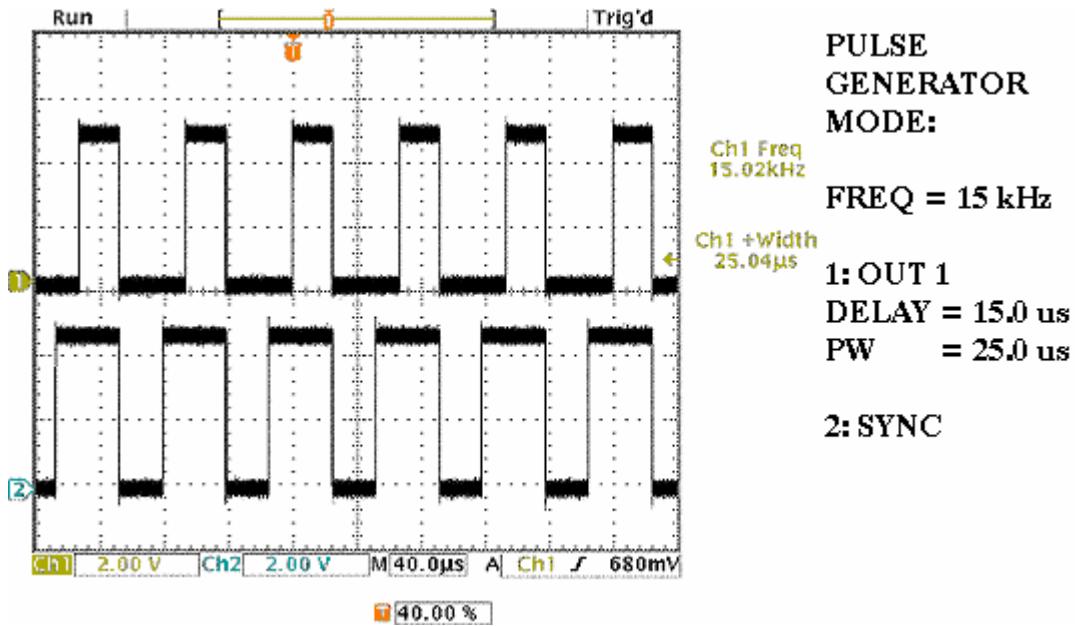


Figure 3 Example 1: Pulse Generator Mode

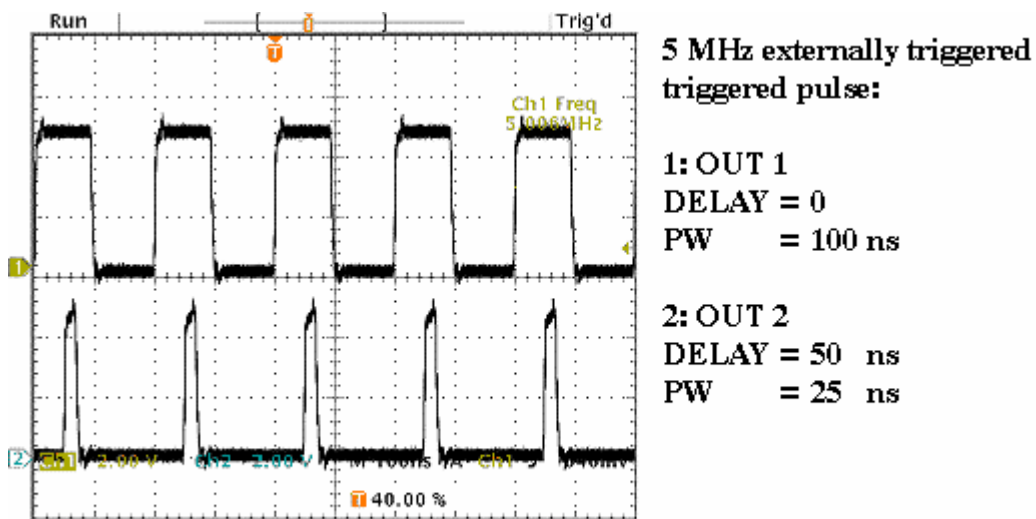


Figure 4 Example 2: Pulse Generator Mode

### Pulse Count Mode

In Pulse Count Mode, the PDG-2515 generates a series of pulses, the number of which is set by the *PULSE CT* variables on the respective channel menu. When the number of pulses output on an output channel equals the number set, the output of that channel is automatically disabled and the output LED will reflect this

The *PULSE CT* variable for each channel can be set to any value between 1 and 65,535. In setting the *PULSE CT*, the x10 button will increase this number by a factor of ten and the encoder wheel will increase/decrease the number of pulses incrementally by one. For example, to set the count to 1,500, first set the count to 15 using the encoder wheel, then press the X10 button two times. The first press will increment the count to 150, and the second to 1,500.

Pressing the OUTPUT button enables the output pulse series. The Pulse On LED will illuminate until the pulse series is completed, at which time the LED will extinguish. Each time the PULSE ON button is pressed, the output pulse series will be generated.

In Internal PRF mode, the frequency (repetition rate) of the pulses are determined by the internal frequency generator. If externally triggered, the frequency of the pulses is determined by the frequency of the input trigger.

The delay of each of the outputs is relative to the leading edge of the T0 SYNC output.

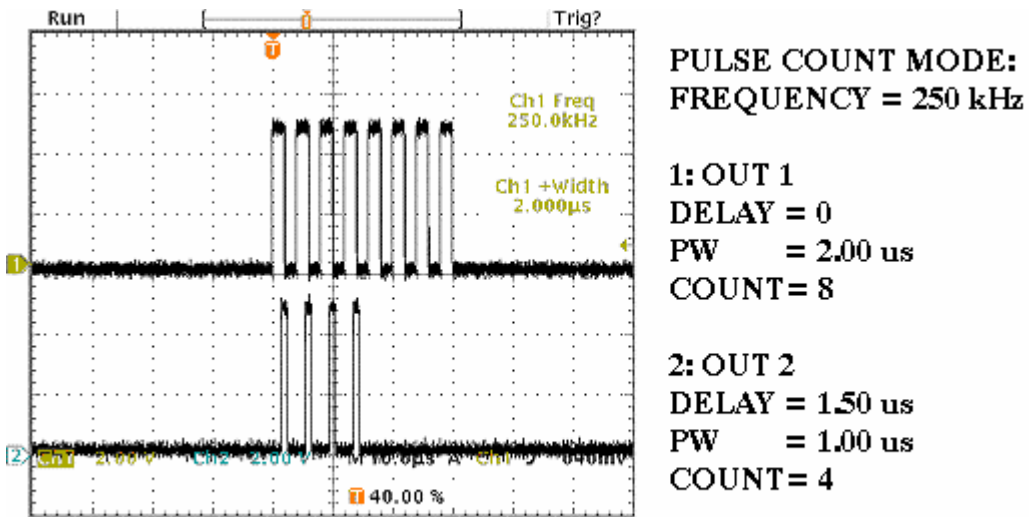


Figure 5 Example: Pulse Count Mode

**Divide By N Mode**

In *Divide by N Mode*, *OUT1* generates continuous output pulses (as in *Pulse Generator Mode*), and *OUT2* generates an output pulse every “Nth” *Output 1* pulse. The divisor is set through the *Div Out1 By* variable in the *FREQ DIV in the CHANNEL2* menu. The X10 button will multiply this number by a factor of 10.

Be aware that coming out of this mode, if any variables are out of range by going into a mode that conflicts with these settings, the channel/channels will be set back to the default values.

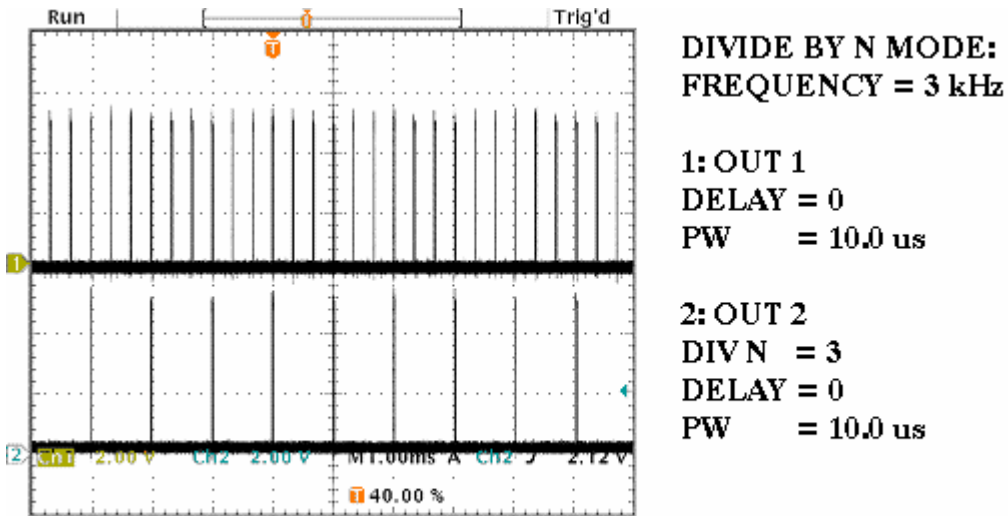


Figure 6 Example 1: Divide by N Mode

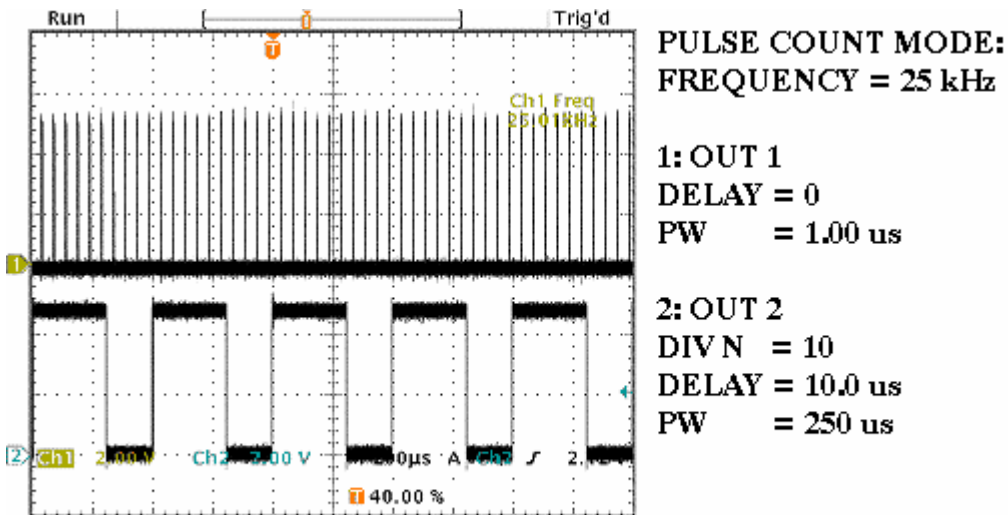


Figure 7 Example 2: Divide by N Mode

**Burst Mode**

In *Burst Mode*, a set number of pulses (the burst packet) are output from OUT1. Each burst packet is sent at the packet frequency. The burst packet will start ONE period of the burst packet frequency after the rising edge of the packet frequency (OUT 2 will ALWAYS output the packet

frequency at a limited duty cycle and cutoff any length of burst after that length of time). The software will not check to check timing constraints in this mode, meaning that if the timing is violated, the output may be erroneous and not predictable (only while the constraints are violated – for example if the number of bursts exceeds the time period of the packet frequency this would violate the hardware of the unit). Violating the timing can be a number of things such as a burst frequency larger than the packet frequency, more pulses/delays than allowed in a single packet so that timing overlaps, etc. The timing constraints are left up to the user's configurations so that the unit may be used to it's full potential, however the user may want to output a signal that does not violate any timing constraints to receive a correct burst and frequency.

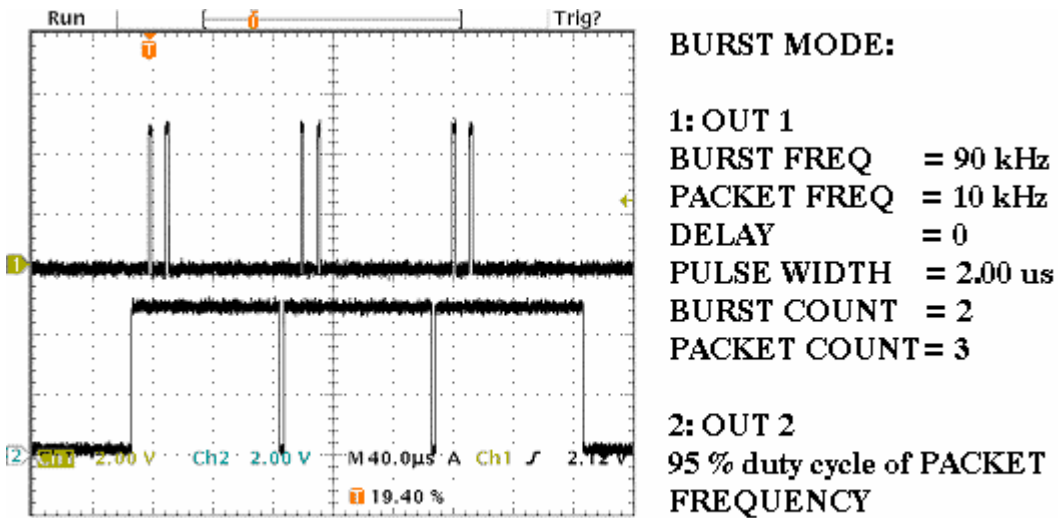


Figure 8 Example: Burst Mode

### Single Shot Mode

In this mode, the pulse widths and the pulse delays can be set to their maximum values without any timing constraints. After the OUTPUT button is depressed, OUT1 and OUT2 will generate a single pulse according to the individual channel settings.

## Troubleshooting Guide

No power LED or screen does not come up.	Check power source, power switch (located on rear of unit).
Pulse exhibits excessive ringing.	Check load impedance.
Frequency limits.	Check duty cycle of EACH channel, both channels must be within the specifications of the unit to increase the frequency. Note that duty cycle of a channel is the addition of the pulse width and the delay.
Pulse Width limits.	Check the frequency and duty cycle. Note that duty cycle of a channel is the addition of the pulse width and the delay settings.
Pulse Delay limits.	Check the frequency and duty cycle. Note that duty cycle of a channel is the addition of the pulse width and the delay settings.
In external trigger pulse is not stable or consistent with settings.	Check duty cycle of input trigger signal, check that the signal frequency and trigger signal duty cycle are within specification.
In Burst Mode pulse is not stable or consistent with settings.	Check to make sure timing constraints are not exceeded; duty cycle of frequency is not exceeded with the addition of extra pulses.
Configuration will not load.	Make sure a valid configuration had been previously saved in configuration slot.
Sync output not a square wave or has excessive ringing.	Check sync lines termination; note that sync does not have same impedance as output lines.



## PDG-2520 Operating Manual

### Quick Start Guide

This quick-start guide provides a step-by-step guide to manually operating the PDG-2520. Please refer to the appropriate sections of the manual for additional instructions and guidelines. The SAFETY warnings in the manual must be read and understood prior to operating the PDG-2520.

#### ***What's In The Box?***

- 1ea. PDG-2520 Digital Delay & Pulse Generator
- 1ea. Power Cord
- 2ea. 50 Ohm Coaxial Output Cable
- 1ea. Operating Manual

#### ***Unpacking***

Carefully remove each component listed above. Your PDG-2520 and accessories were inspected at the factory prior to shipment. Inspect the PDG-2520, power cord and output cables for signs of shipping damage. If any damage is noted contact the factory prior to operating the equipment.

#### ***Setup***

Connect *OUTPUTS* to an appropriate load using 50 Ohm coaxial cable (included).

Plug the AC power cord into the rear power entry module of the PDG-2520, and into an appropriate AC socket.

#### ***Power Up***

Turn on the PDG-2520 by pressing the **power** button located above the power entry module in the rear of the unit.

The front panel display will read initialize and display the software and hardware versions internal to the unit on the front panel. After a few moments the unit will finish initialization and the first screen/menu that will appear is the menu for CHANNEL 1. Note: The buttons and encoder on the front panel will have no effect as the unit comes up from initialization.

### ***Front Panel Controls & Connections***

#### **Encoder**

This is for varying the parameters such as Frequency, Pulse Width, Delay, Trigger Source, etc.

**Output Button**

The output button enables/disables the pulse output.

**Menu Button**

This button is for navigating the PDG-2520 menus.

**Enter Button**

Used for variables that will be permanently stored in the unit or require setup times internal to the PDG-2520. When a question mark appears after the variable, the enter button will “confirm” or in some cases save that particular setting.

**Up Arrow Button**

The UP ARROW button allows the user to go up in any particular menu to change selections. If the user is at the top selection it will wrap back around to the bottom selection.

**Down Arrow Button**

The DOWN ARROW button allows the user to go down in any particular menu to change selections. If the user is at the bottom selection it will wrap back around to the top selection.

**X10 Button**

The X10 button is used when varying parameters that have exponents that can change by a power of 10. By pressing the X10 button the user can increment the exponent within its acceptable range. This allows the user to quickly set the parameters, without having to excessively scroll the encoder wheel. The X10 button functions with the following commands:

Set Pulse Width 1, 2, 3, and 4

Set Delay 1, 2, 3, and 4

Set Frequency (\*Note: if depressed while dialing in frequency it will increase the frequency at a much higher rate)

Set Counters/Bursts/Packets

The X10 button is effectively a 10X multiplier. For example, when setting frequency, the resolution of the encoder wheel is three digits (i.e. 1.00Hz, 10.0Hz, 100Hz, 1.00KHz). Therefore without adjusting the range, the encoder wheel must be turned many times to increase the frequency from 1Hz to 100Hz. However if the frequency is set to 1.00Hz, if the X10 button is pressed once, it changes to 10.0Hz. If it is pressed twice, it changes to 100Hz.

Setting the delay and pulse width is similar to setting frequency. For example, to set the delay to 300ns, set the delay to 25ns, press the

X10 button once to increment it to 250ns, then rotate the encoder wheel to increase it to 300ns. At this point, pressing the X10 button again would increase the delay to 3.00us, pressing it again increments it to 30.0us, etc.

An additional function is that if it is held while changing ANY frequency value, after multiplying the value by a factor of ten, if the encoder is moved it will increase/decrease at a much faster rate. This makes the switching frequency much quicker and easier.

### **PW/PRF Button**

This is for varying the parameters Frequency and Pulse Width and toggling between the two settings quickly. If you are in any menu that is not a CHANNEL MENU, it will flip you immediately to the CHANNEL 1 menu and the FREQUENCY setting.

### **Out 1, Out 2, Out 3, Out 4**

These are the pulse output connectors. The outputs of the PDG-2520 should be connected to the inputs of the receiving instrument or system using 50 Ohm coaxial cable. For optimal pulse fidelity, these outputs should be terminated into 50 Ohms.

### **Sync Out**

This is a 5V signal into 1 meg-Ohm or 2.5V signal into 50 Ohms that is synchronous with the frequency generator trigger. This is designed to assist the user in triggering when monitoring the output signals with an oscilloscope, or for use in triggering an external instrument.

### **Trigger In**

This is an input signal into 1KOhms used for external Pulse Repetition Frequency (PRF) triggering. It is designed to allow the user to trigger multiple PDG-2520 units from a single pulse generator. This allows the user to create synchronous waveforms from multiple units.

### **Power LED**

Indicates that the power switch on the rear of the unit is in the 'on' position and that AC power is applied to the unit.

## ***Front Panel Controls & Connections***

### **AC Power Entry Module**

The driver is grounded through the grounding conductor of the AC power cord. To avoid electrical shock, plug the driver into a properly wired receptacle before making connection to any input or output connectors. Use only a power cord that is in good condition.

The PDG-2520 accepts input voltages of 90-264VAC, 47-63Hz.

### ***Example Setup***

The default setup is 1 kHz, with zero delay and 100 us pulse on both channels. The pulse is not inverted and the pulse mode is in continuous pulse generation mode which means that pulse count is not available. By pressing the **OUTPUT** button on the front panel you will see these pulses on the respective outputs.

Turning the encoder with the pulses enabled and the unit will sweep the frequency on the fly, hitting the **X10** button will bring you to 10 times the frequency. Pressing the down arrow twice will highlight the pulse width selection. Turn the encoder and the width will sweep. Try this with the polarity setting; it will change on the fly. Turn off the pulses.

Press **MENU** to continue to the settings for CHANNEL 2. Its default is the same as CHANNEL 1. Pressing the **MENU** button twice more will bring the user through to the last channel menu.

Hitting **MENU** again will bring up the first output menu, OUTPUT MENU1. This menu allows the unit to change pulse modes, disable and enable the outputs (depending on the pulse mode), and choose whether the sync is based off CHANNEL 1, 2, 3, or 4.

Hitting **MENU** again will bring up the second output menu, OUTPUT MENU2. This menu allows the unit to select the trigger, adjust the contrast, and select the logic applied to the output of CHANNEL 1, 2, 3, and 4.

Hitting the arrow keys allows the user to decide which settings on the current menu they would like to adjust. Press the up arrow once to scroll around to the bottom of the menu or press the down arrow 5 times. The contrast setting will be highlighted.

Turn the encoder to adjust the contrast. The contrast will adjust “on the fly” and a question mark will appear at the end of the contrast. Hit ENTER and save the contrast saving into the non-volatile memory of the unit, this setting will be saved into the unit and keep this in memory even after power-down.

## Product Overview

### *Description*

The PDG-2520 is a four channel digital delay/pulse generator. Each channel offers independently adjustable delay and width, with 25 nanosecond resolution. Up to five user configurations may be stored in internal non-volatile memory, and recalled through the easy to understand front panel.

### *Functions & Features*

<b>Delay And Width and Duty Cycle.</b>	Each channel provides independently adjustable delay and width, with 25ns resolution. The duty cycle is limited based on the frequency. The duty cycle is limited approximately by the equation: $\text{MAX DC} = 97 - [(1E-5) * \text{FREQ}]$
<b>Frequency</b>	Pulse repetition frequency from single shot to continuous pulses from 100 mHz to 3.0 MHz.
<b>Resolution</b>	100mHz to 1.0 MHz -> 3 digits 1.0 MHz + -> 2 digits
<b>Trigger Sources</b>	Internal, External, Single Shot.
<b>Pulse Generator Mode</b>	Generates pulses at the rate set by the internal frequency generator, or by an external trigger.
<b>Pulse Count Mode</b>	Outputs pulses at the rate set by the internal frequency generator or external trigger and stops after N pulses.
<b>Divide By N Mode</b>	Channel 1 and Channel 3 operates in continuous mode. Channel 2 and Channel 4 pulses every Nth pulse.
<b>Burst Mode</b>	Generates a burst of pulses, repeating at a frequency on Channel 1.
<b>Counted Burst Mode</b>	Generates a burst of pulses, and stops after N bursts.
<b>Store And Recall</b>	Stores up to 5 user configurations in non-volatile memory.

## Specifications

PARAMETER	Value
<b>OUTPUTS</b>	
Output Channels	Four (4) outputs, each with independent digitally controlled delay and pulse width
Delay Range	0 to 99.9 Seconds
Pulse Width Range	25 Nanoseconds to 99.9 Seconds
Delay And Pulse Width Resolution	25 Nanoseconds below 1 Microsecond 50 Nanoseconds from 1 Microsecond to 10 Microseconds 3 Digits Above 10 Microseconds
Accuracy (Delay and Pulse Width)	±2%
Time Base	120MHz Frequency Synthesizer
Delay Jitter (1 <sup>st</sup> Sigma)	TBD
Trigger Delay (External Trigger to SYNC (T <sub>0</sub> ) Output)	TBD
Internal Throughput Delay (SYNC (T <sub>0</sub> ) To Output 1 Or Output 2 Rising Edge)	<25 Nanoseconds
Output Rise & Fall Times (Into 50Ω)	<5 Nanoseconds
Over/undershoot	<5%
Amplitude	+4V into 50W
Output Connectors	BNC, Front Panel
<b>INTERNAL RATE GENERATOR</b>	
Modes	Continuous, Single-Shot, Burst, External Trigger, Divide By N, Pulse Count
Rate	Single-Shot or 100 millihertz to 3MHz (Internal) Single-Shot to 5MHz (External Trigger)
Resolution	3 Digits (<1MHz), 2 Digits (>1MHz)
Accuracy (Continuous, Pulse Count, Output-2 Modes)	25 PPM
Accuracy (Burst Mode)	±2%
Rate Jitter (Continuous, Pulse Count, Output-2 Modes), 1 <sup>st</sup> Sigma	TBD
Rate Jitter (Burst Mode), 1 <sup>st</sup> Sigma	TBD
Burst and Pulse Count Mode	1 to 65,535 Pulses per Burst or Count
<b>EXTERNAL TRIGGER INPUT</b>	
Type	Positive Edge Trigger
Input Amplitude	TTL into 1KΩ
Input Impedance	1KΩ
Minimum Trigger Pulse Width	25ns
Input Trigger Connector	BNC, Front Panel
<b>T<sub>0</sub> (SYNC) OUTPUT</b>	
T <sub>0</sub> (Sync) Output	TTL output into 1 MegΩ, 4.5V into 50Ω
Connector	BNC, Front Panel
<b>COMPUTER INTERFACE</b>	
Interface Type	RS232 or GPIB
Interface Connector	DB9 or GPIB connector
<b>GENERAL</b>	
Internal Non-Volatile Storage	5 Configurations
Operating Temperature Range	0°C to +40°C
Cooling Requirements	Air cooled
Input AC Power	90-264VAC, 47-63Hz, 28W Maximum
Dimensions (H X W X D)	3 ½" H x 8" W x 6 1/4" D (8.9cm H x 20.3cm W x 15.9cm D)
Weight	2 lbs. (.9kg) Approximate

## ***Applications***

The versatile functionality of the PDG-2520 makes it ideal for the needs of numerous applications as a small bench top instrument. The delay resolution and width resolution of each channel allow a unique ability to offset control signals, coupled with ability to logically manipulate the outputs together to form gate signals or specific waveforms make automation of testing and control an easier process.

## **Safety**

Normal use of test equipment exposes the user to a certain amount of danger from electrical shock because testing may be performed with exposed voltages present, dictating the use of caution when operating or servicing this equipment. The following is a summary of general safety precautions that must be observed during all phases of operation and repair of the PDG-2520.

### ***Operating Safety Summary***

The safety information contained in this summary is for both operating and servicing personnel. Specific warnings may be found throughout this manual, but may not appear in this summary.

#### **Power Source**

The PDG-2520 is designed to operate from a regulated power source. To assure proper system operation the input voltage should not vary by more than 10% from the recommended specification. The PDG-2520 accepts input voltages from 90VAC to 264VAC at 47Hz to 63Hz.

A protective grounding connection by way of the grounding conductor in the AC power cord is essential.

#### **Grounding**

The PDG-2520 is grounded through the grounding conductor of the AC power cord. **To avoid electrical shock, plug the PDG-2520 into a properly wired receptacle before making connection to any input or output connectors.** Use only a power cord that is in good condition.

#### **Cover Removal**

To avoid personal injury, do not remove the covers. **Do not operate the PDG-2520 while the covers are removed.** Operating the unit with the top cover removed voids any and all warranties associated with the PDG-2520.

#### **General Operating Precautions**

Do not open the unit while the system is in operation. Use caution when handling or removing the output cables while the unit is operating. Turn off

equipment when making connections in high voltage or high current circuits. Discharge high voltage capacitors after removing power.

### ***Servicing Safety Summary***

DEI strongly recommends that all repairs and adjustments be performed by factory qualified personnel. DEI will not be responsible for personal injury or damage to the pulse generator that occurs during repair by any party other than the factory. Any repairs, adjustments or modifications made by anyone other than authorized DEI personnel voids the factory warranty.

### ***PREPARATION FOR USE***

#### **General**

After unpacking, initial inspection and electrical installation procedures should be performed to assure that the unit is in good working order. If it is determined that the unit is damaged, the carrier should be notified immediately. Repair problems should be directed to the service department,

Directed Energy, Inc. (DEI),  
Fort Collins, Colorado.  
Telephone: (970) 493-1901  
FAX: (970) 493-1903  
EMAIL: deiinfo@directedenergy.com

#### **Initial Inspection**

- Inspect unit for exterior mechanical damage.
- Inspect power input cord and input power module for obvious signs of damage.

#### **Electrical Installation**

Standard units are shipped ready for use with a nominal 90 - 264 VAC input.

### **Operation**

This section provides basic operating instructions for the PDG-2520 hardware.

#### ***Operating Tips***

1. The four output channels have synchronized frequencies. Pulse width and pulse delay settings of one channel are dependent on the frequency of the other channels. When changing frequency be aware that both pulse width and delay are within range on both channels.
2. When using the 10X button to increase the rate at which the frequency changes, when it is first depressed the value will change by 10X, further



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change is accomplished by using the encoder while holding the 10X button down.

### **Power-Up Procedures**

The unit should be powered up using the following procedures:

Connect *OUTPUTs* to an appropriate load using 50 Ohm coaxial cable (See Section 6.0).

Plug the AC power cord into the PDG-2520, and into an appropriate AC socket.

Turn on the PDG-2520 by pressing the **power** button on the rear of the unit located above the power entry .

Configure the unit from the front panel. See the quick-start guide in Section 1.0 of this manual for specific operating instructions, and Sections 8 and 9 for detailed operation instructions.

## **FRONT PANEL OPERATING INSTRUCTIONS**

### **THE CHANNEL MENU**

The CHANNEL MENU will display which channel menu the unit is in on the top of the display. Changing the settings is done by simply rotating the encoder or pressing the **X10** button. When the setting has reached it's maximum value on the encoder it will stop increasing the value as the encoder turns. The X10 button on the other hand will set the value to the nearest minimum exponent value when the maximum value has been reached (example: 500 kHz will go to 500 mHz). This maximum value is set by the internal limitations of the unit and also the pulse settings (ie: pulse delay and duty cycle). In order the change which setting to adjust the up and down arrows will highlight the current setting. In the CHANNEL MENU all settings can be done while the unit is enabled, all settings can "sweep". Changing the pulse width and delay settings while enabled will not effect the pulse, the change will take place on the next available clock cycle internally. The frequency needs to be stopped and adjusted and then turned back on internally. This means that there could be some delay while sweeping frequency before the next frequency takes hold, this is more noticeable as the frequency is near to slower limits while the unit syncs up again to the internal oscillator. The polarity sweep will take hold immediately, as will the disable and enable functions. The polarity function will flip the polarity of the output. Pulse count will only be available in pulse count and burst modes.

### **OUTPUT MENU1**

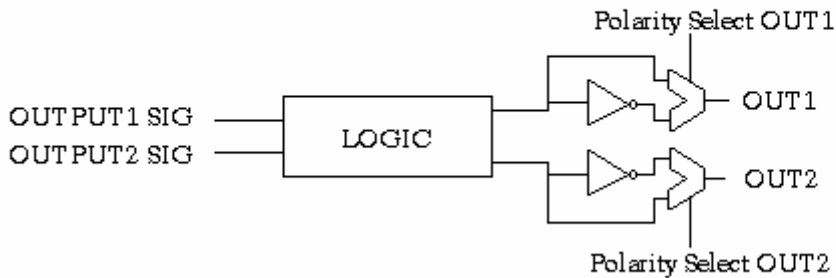
OUTPUT MENU1 is the menu where the unit can change its mode, disable/enable a channel, and change the base of the sync. The operating

modes will be discussed in more detail in section 9.0. Enabling and disabling a channel can also happen on the fly in all modes except Burst Mode. In Burst mode, enabling/disabling the channels is not available and Channel 1 and 2 are enabled, Channel 3 and 4 are disabled automatically. When the mode is switched from Burst mode, the enable/disable settings will return to where they were previous to Burst mode. The trigger can be set to internal or external in pulse generation and pulse count modes. Note that the unit will “lock up” until it has finished it’s pulse count in external mode so the external triggering device must give it AT LEAST as many pulses as is entered. If this does not occur, the device can be “released” by switching modes. The sync can also be run off any channel except under Burst Mode. This is especially useful in Divide By N mode and pulse count mode. Not that in Burst mode, the sync is a packet period limited by at most 95% duty cycle regardless of this setting.

## **OUTPUT MENU2**

OUTPUT MENU2 is where the unit can change the trigger, adjust the contrast settings of the unit, and set the logic applied to the output of all Channels. The operating modes will be discussed in more detail in section 9.0. The trigger can be set to internal or external in pulse generation and pulse count modes. Note that the unit will “lock up” until it has finished it’s pulse count in external mode so the external triggering device must give it AT LEAST as many pulses as is entered. If this does not occur, the device can be “released” by switching modes. The sync can also be run off any channel when the unit is not in Burst mode (Note that in Burst mode, the sync is a packet period limited by at most 95% duty cycle regardless of this setting and outputs on Channel2 as well as the SYNC output. The contrast setting can also be changed in this menu. If the contrast is adjusted by using the encoder knob or using the x10 button, a ‘?’ will appear at the end of the setting. This means that while the unit is powered this is the setting that the unit will retain but when powered down and powered up again the unit will revert to the last saved contrast. By depressing the ENTER button the contrast will be saved in non-volatile memory and the unit will come up under this contrast setting. The contrast is has numerous settings, and a coarse and a fine adjust. The letter is a course adjustment and the number is the fine adjust. The course adjust is manipulated with the x10 button and the fine adjust is set by the encoder knob. Logic allows the user to logically AND or OR outputs OUT1 and OUT2 with each other and OUT3 and OUT4 with each other. LOGIC1 will output on the OUT1 channel (note: the invert function will invert the channel AFTER the logic has been applied – this is shown in the LOGIC AND POLARITY FUNCTIONAL DIAGRAM below). LOGIC2 will output on the OUT2 channel, LOGIC3 will output on the OUT3 channel, and LOGIC4 will output on the OUT4 channel.

LOGIC AND POLARITY  
FUNCTIONAL DIAGRAM.



**Figure 9 Logic & Polarity Functional Diagram**

### THE CONFIGS MENU

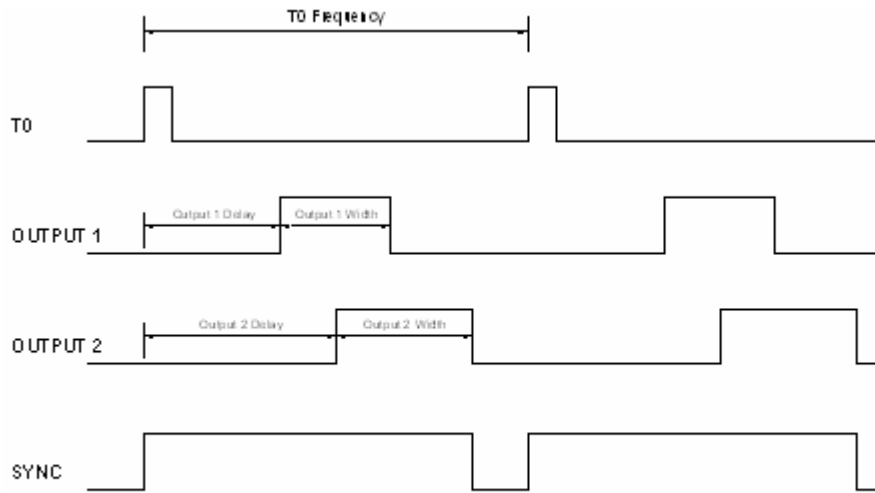
The CONFIGS MENU allows the user to save or load up to 5 different configurations. After selecting the appropriate configuration to either load or save (1 through 5) hit the ENTER button and the configuration of the unit will be saved. If the user tries to load a configuration that has not been saved yet, the unit will send an error message of "Not Valid Config" and nothing will be loaded. If the load or save is successful the active configuration (ACTIVE CON: X) will reflect this with the correct setting.

\*Note: if any values are changed, the active configuration will no longer be valid and will reflect either -- or a '0'.

### ***Operating Modes***

#### **Timing Diagram**

The timing diagram below defines the frequency, delay and width variables, and their temporal relationship to the T<sub>0</sub> frequency generator signal.



\*SYNC based on OUT 2 in unit

**Figure 10 Timing Diagram**

Please note that in external trigger mode, all outputs are delayed from the leading edge of the external trigger signal.

**Pulse Generator Mode**

In Pulse Generator Mode, the PDG-2520 generates pulses at the specified frequency denoted in the CHANNEL MENU (changing the frequency on either channel will change the frequency on both channels simultaneously – the frequencies are not independent in this mode). If externally triggered, the rate is set by the external trigger (i.e. one pulse is output each time a rising edge occurs on the TRIGGER input).

The delay of each of the outputs is relative to the leading edge of the SYNC output in internal frequency generator and single shot modes. In external trigger mode, the delay is relative to the leading edge of the external trigger input.

The pulse width and delay for each channel are independently variable.

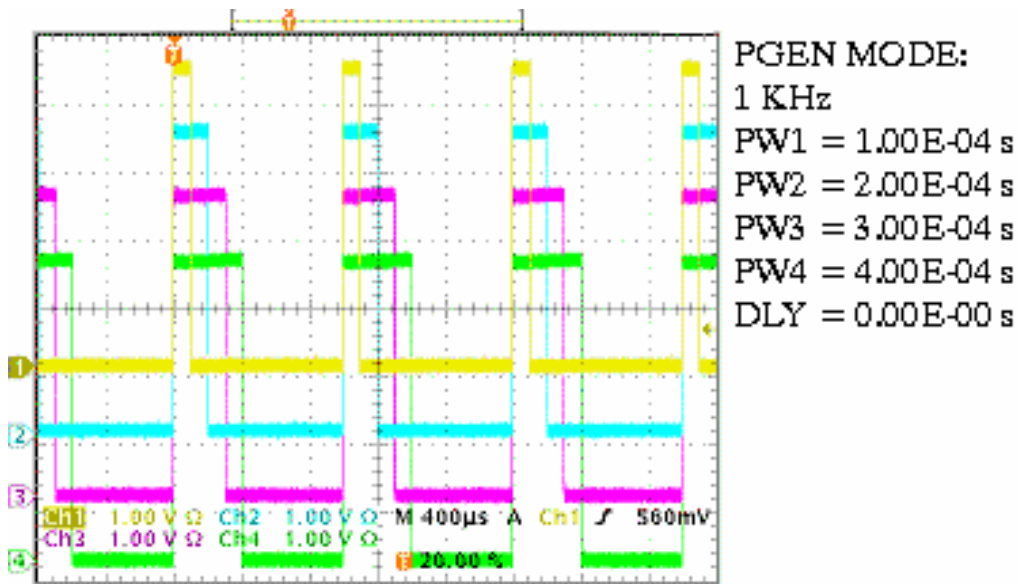


Figure 11 Example 1: Pulse Generator Mode

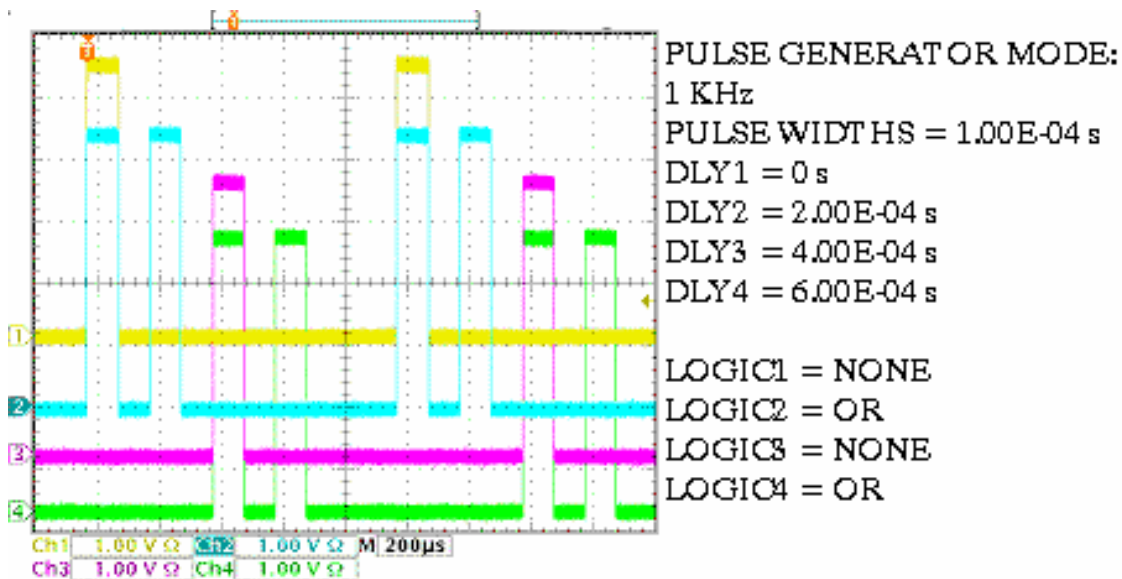


Figure 12 Example 2: Pulse Generator Mode with logic

### Pulse Count Mode

In Pulse Count Mode, the PDG-2520 generates a series of pulses, the number of which is set by the *PULSE CT* variables on the respective channel menu. When the number of pulses output on an output channel equals the number set, the output of that channel is automatically disabled and the output LED will reflect this

The *PULSE CT* variable for each channel can be set to any value between 1 and 65,535. In setting the *PULSE CT*, the x10 button will increase this number by a factor of ten and the encoder wheel will increase/decrease the number of pulses incrementally by one. For example, to set the count to 1,500, first set the count to 15 using the encoder wheel, then press the X10 button two times. The first press will increment the count to 150, and the second to 1,500.

Pressing the OUTPUT button enables the output pulse series. The Pulse On LED will illuminate until the pulse series is completed, at which time the LED will extinguish. Each time the PULSE ON button is pressed, the output pulse series will be generated.

In Internal PRF mode, the frequency (repetition rate) of the pulses are determined by the internal frequency generator. If externally triggered, the frequency of the pulses is determined by the frequency of the input trigger.

The delay of each of the outputs is relative to the leading edge of the T0 SYNC output.

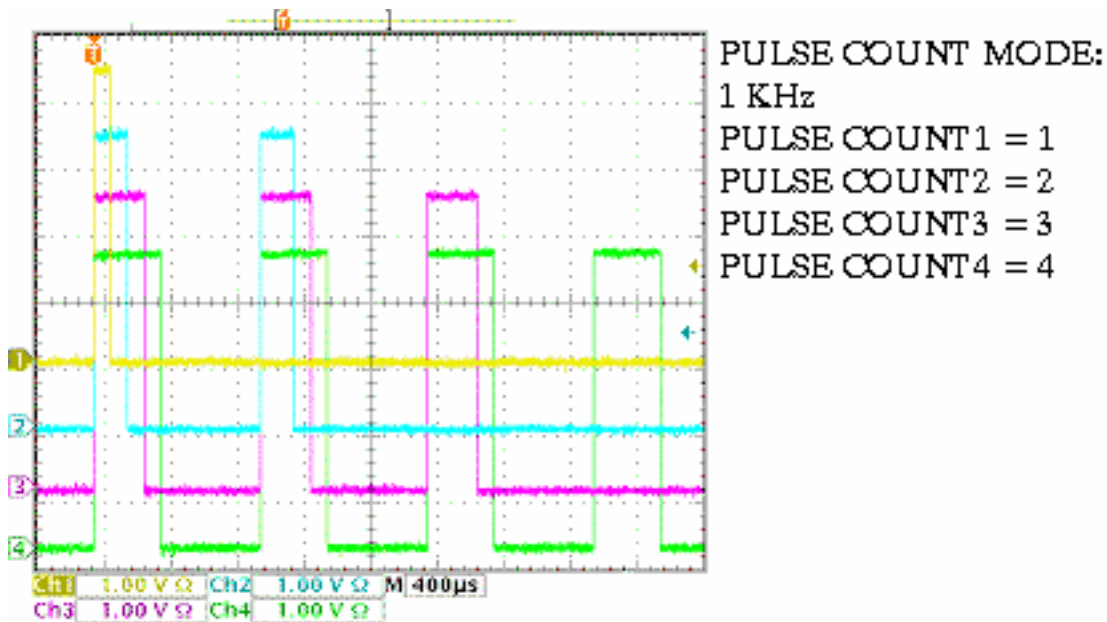


Figure 13 Example: Pulse Count Mode

### Divide By N Mode

In *Divide by N Mode*, *OUT1* and *OUT3* generates continuous output pulses (as in *Pulse Generator Mode*), and *OUT2* and *OUT4* generates an output pulse every “Nth” *Output* pulse. The divisor is set through the *Div Out1 By* variable in the *FREQ DIV in the CHANNEL2* menu. The X10 button will multiply this number by a factor of 10.

Be aware that coming out of this mode, if any variables are out of range by going into a mode that conflicts with these settings, the channel/channels will be set back to the default values. Also be aware that channels 1 and 3 stay synchronized and channels 2 and 4 must have the same value for N. The delays and pulse widths on these channels are all independent.

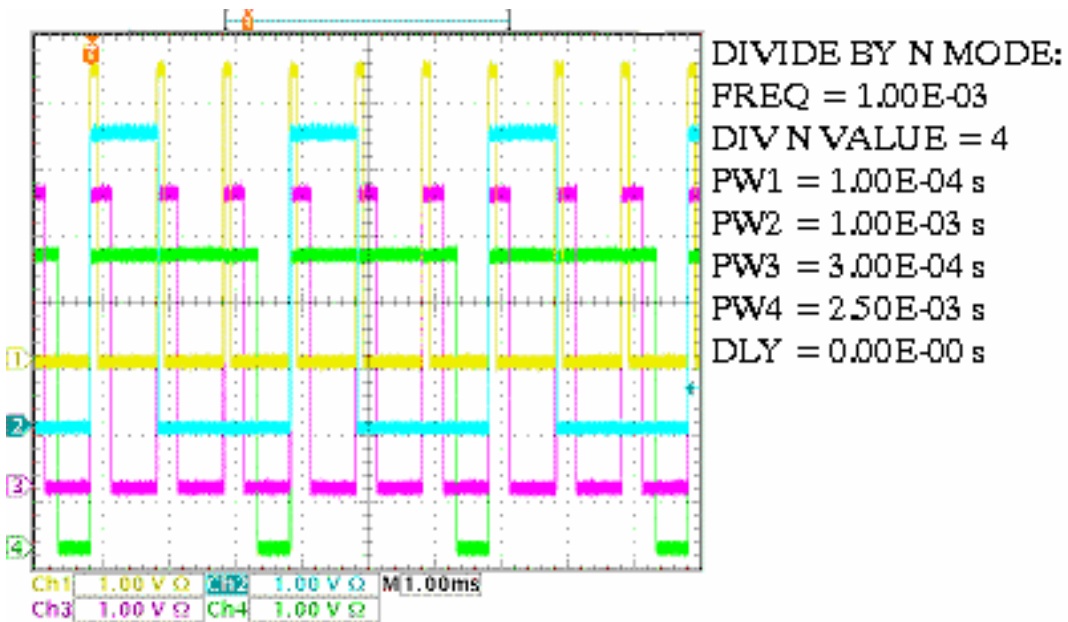


Figure 14 Example 1: Divide by N Mode

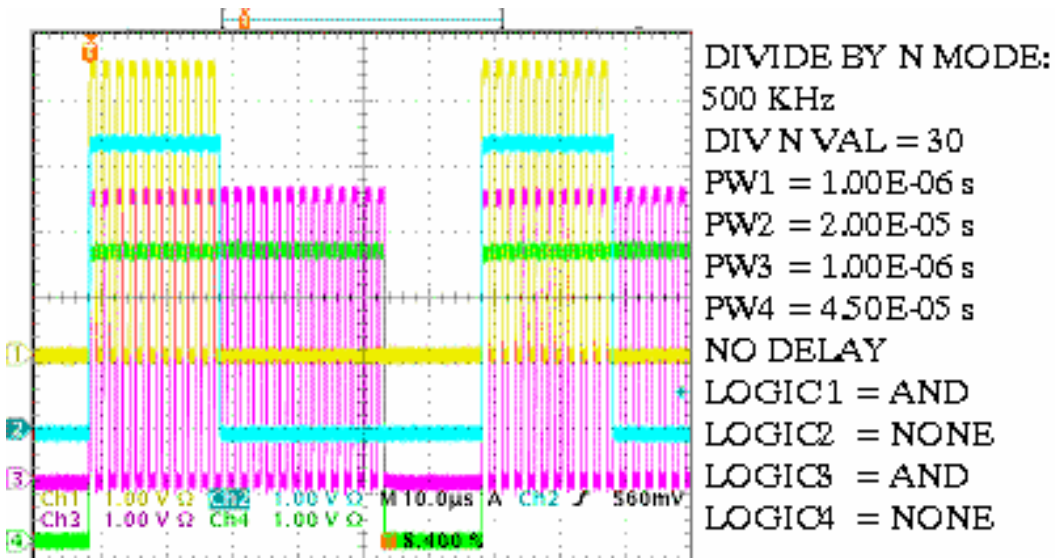


Figure 15 Example 2: Divide by N Mode

**Burst Mode**

In *Burst Mode*, a set number of pulses (the burst packet) are output from OUT1. Each burst packet is sent at the packet frequency. The burst packet will start ONE period of the burst packet frequency after the rising edge of the packet frequency (OUT 2 will ALWAYS output the packet frequency at a limited duty cycle and cutoff any length of burst after that length of time). The software will not check to check timing constraints in this mode, meaning that if the timing is violated, the output may be erroneous and not predictable (only while the constraints are violated – for example if the number of bursts exceeds the time period of the packet frequency this would violate the hardware of the unit). Violating the timing can be a number of things such as a burst frequency larger than the packet frequency, more pulses/delays than allowed in a single packet so that timing overlaps, etc. The timing constraints are left up to the user's configurations so that the unit may be used to it's full potential, however the user may want to output a signal that does not violate any timing constraints to receive a correct burst and frequency. OUT 3 and OUT 4 are not available in this mode, they will stay at DC levels.

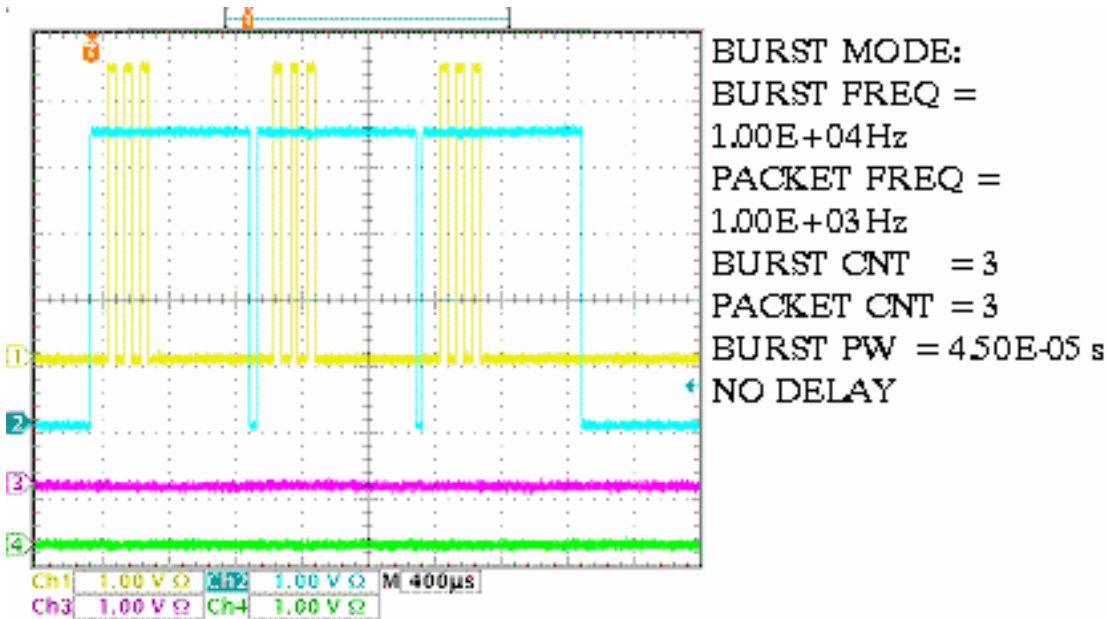


Figure 16 Example: Burst Mode

**Single Shot Mode**

In this mode, the pulse widths and the pulse delays can be set to their maximum values without any timing constraints. After the OUTPUT button is depressed, the OUTPUTs will generate a single pulse according to the individual channel settings.



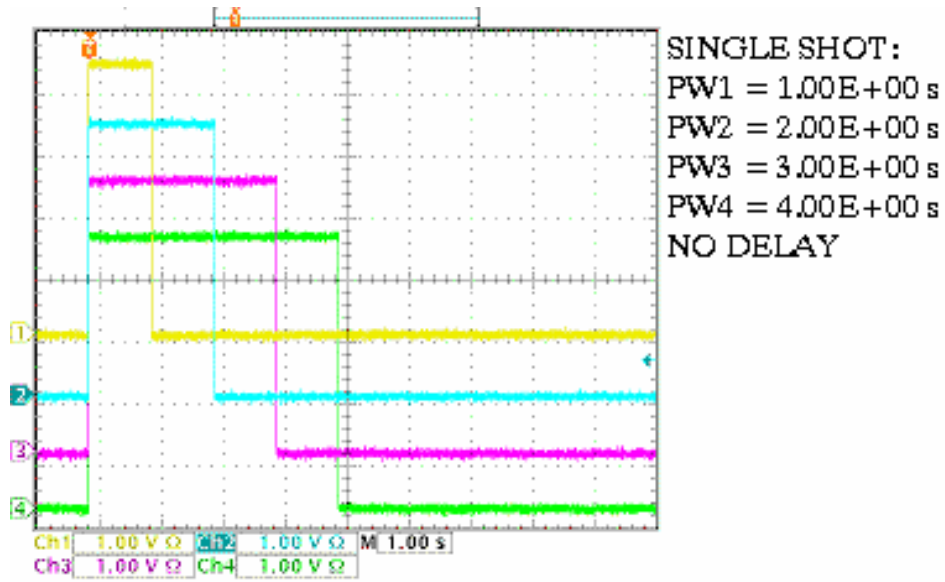


Figure 17 Example: Single Shot Mode

## Troubleshooting Guide

No power LED or screen does not come up.	Check power source, power switch (located on rear of unit).
Pulse exhibits excessive ringing.	Check load impedance.
Frequency limits.	Check duty cycle of EACH channel, both channels must be within the specifications of the unit to increase the frequency. Note that duty cycle of a channel is the addition of the pulse width and the delay.
Pulse Width limits.	Check the frequency and duty cycle. Note that duty cycle of a channel is the addition of the pulse width and the delay settings.
Pulse Delay limits.	Check the frequency and duty cycle. Note that duty cycle of a channel is the addition of the pulse width and the delay settings.
In external trigger pulse is not stable or consistent with settings.	Check duty cycle of input trigger signal, check that the signal frequency and trigger signal duty cycle are within specification.
In Burst Mode pulse is not stable or consistent with settings.	Check to make sure timing constraints are not exceeded; duty cycle of frequency is not exceeded with the addition of extra pulses.
Configuration will not load.	Make sure a valid configuration had been previously saved in configuration slot.
Sync output not a square wave or has excessive ringing.	Check sync lines termination; note that sync does not have same impedance as output lines.

## **Communications and Remote Operation:**

The PDG25xx series of pulse generators have the option of a communications interface. The options are RS232 or GPIB interface. Both interfaces take the same ascii based command set, although the strings are terminated differently. The unit will reply at least one byte on every command with the exception of the changing of the GPIB address, and the changing of the baud rate. This allows the user to communicate as quickly and as efficiently as possible. If the PDG unit has been purchased with communications interface, the front panel will display a REMOTE MODE menu that displays either the current GPIB address or the current baud rate depending on the interface installed in the unit. This is provided so that the user may know how to set up the communications interface from a remote terminal upon powering up the unit if the communications settings are unknown.

### ***RS232 Operation:***

The default baud rate on the RS232 interface is 115200. Switching the baud rate is possible, and will be saved in non-volatile memory, but the unit will not respond in a command to make GUI interfaces easier to implement without closing out and re-opening a COMM PORT before a reply is issued. The send and return strings are ASCII based framed after a SCPI protocol. The string is TERMINATED BY A RETURN ('\r') CHARACTER. After the unit receives the return character the command will be parsed, processed and a reply will be generated so that the next command may be sent. Be aware that some commands complete significantly faster than others, the load and save configuration command could take up to 400 milliseconds to complete due to the overhead associated with the commands. The response from the unit will be terminated with a '\r' character as well; this makes the implementation and design of a GUI much simpler and more efficient than a timeout.

### ***GPIB Operation:***

The default address of the GPIB interface is 1. Switching the address is possible and will be saved in non-volatile memory, but be aware that the unit will not respond in a command to make GUI interfaces easier to implement without closing out and re-opening a new address on the remote interface before a reply is issued. The send and return strings are ASCII based framed after a SCPI protocol. The string is TERMINATED BY AN EOI line assertion – there is no termination character, sending one will only end in a communications error. After the unit receives the EOI the command will be parsed, processed and a reply will be generated so that the next command may be sent. Be aware that some commands complete significantly faster than others, the load and save configuration command could take up to 400 milliseconds to complete due to the high overhead. The response from the unit will be terminated with a EOI as well, this makes the implementation and design of a GUI much simpler.

**Reply:**

The reply generated will be either response to the data sent to the unit, as in a query, or an error code. The error code will be prefaced by a '#' and then the ascii code itself. The codes are explained below. The error code, whether it is 0 (which indicates NO ERROR) or a valid error is prefaced by the '#' character to distinguish the data from a valid reply. For example, if the pulse width was queried (CHNx:PULS:WIDT?), a valid response would not have a '#' character as the first character, but if there was an error (such as invalid channel, parse error, etc.) the response would send a '#' character as it's first byte.

**The ASCII commands:**

The commands sent are in four letter words separated by a colon. The data is separated by a single white space character (0x20) and is in the form x.XXE+xx. For example, to set the frequency to 1.35 KHz you would send the string CHAN:PULS:FREQ 1.35E+03. Each channel in the unit is distinguished by a CHNx, where x is the channel the remote is talking to. For example, to set the pulse width of channel 2 to 150 us, the string sent would be CHN2:PULS:WIDT 1.50E-04.

**The Command Set:**

WORD			DATA	OPERATION	COMMAND
CHAN	PULS	FREQ	X.XXE+XX	READ,WRITE	SET PULSE FREQUENCY
	BRST	FREQ	X.XXE+XX	READ,WRITE	SET BURST FREQUENCY
		DLAY	X.XXE+XX	READ,WRITE	SET BURST DELAY
		WIDT	X.XXE+XX	READ,WRITE	SET BURST WIDTH
		CNTR	integer	READ,WRITE	SET BURST COUNT
	PKET	FREQ	X.XXE+XX	READ,WRITE	SET PACKET FREQUENCY
		CNTR	integer	READ,WRITE	SET PACKET COUNT
CHNx	PULS	DLAY	X.XXE+XX	READ,WRITE	SET CHANNEL x's DELAY
		WIDT	X.XXE+XX	READ,WRITE	SET CHANNEL x's WIDTH
		CNTR	integer	READ,WRITE	SET CHANNEL x's COUNT
		LOGC	0	READ,WRITE	SET NO LOGIC ON CHANNEL x
			1		SET "AND" LOGIC ON CHANNEL x
			2		SET "OR" LOGIC ON CHANNEL x
		DVAL	integer	READ,WRITE	SET CHANNEL x's DIV N VALUE
		DCYC	unsigned char	READ,WRITE	SET CHANNEL x's DUTY CYCLE
	INVT		0	READ,WRITE	CHANNEL x NOT INVERTED
			1	READ,WRITE	INVERT CHANNEL x
	STAT		0	READ,WRITE	DISABLE CHANNEL x
			1	READ,WRITE	ENABLE CHANNEL x
OUTP	MODE		0	READ,WRITE	SET MODE TO PULSE GENERATOR
			1	READ,WRITE	SET MODE TO PULSE COUNT MODE

			2	READ,WRITE	SET MODE TO DIVIDE-BY-N MODE
			3	READ,WRITE	SET MODE TO BURST MODE
			4	READ,WRITE	SET MODE TO INTERNAL SINGLE SHOT
	TRIG		1	READ,WRITE	SET CHANNEL TO INTERNAL TRIGGER
			2	READ,WRITE	SET CHANNEL TO EXTERNAL TRIGGER
	STAT		0	READ,WRITE	DISABLE PULSING
			1	READ,WRITE	ENABLE PULSING
	SYNC		x	READ,WRITE	SET SYNC TO CHANNEL x
SYST	CONF	LOAD	x	WRITE	LOAD SYSTEM CONFIGURATION x
		SAVE	x	WRITE	SAVE CONFIGURATION x
	FIRM	VERS	N/A	READ	GET FIRMWARE VERSION OF UNIT
	HDWR	VERS	N/A	READ	GET HARDWARE VERSION OF UNIT
COMM	GPIB	ADDR	x	READ,WRITE	SET GPIB ADDRESS x (x = 1-30)
	SERL	BAUD	1	READ,WRITE	SET RS232 BAUD RATE TO 9600
			2		SET RS232 BAUD RATE TO 14400
			3		SET RS232 BAUD RATE TO 19200
			4		SET RS232 BAUD RATE TO 28800
			5		SET RS232 BAUD RATE TO 38400
			6		SET RS232 BAUD RATE TO 57600
			7		SET RS232 BAUD RATE TO 115200
	FIRM	VERS	N/A	READ	GET COMMUNICATIONS VERSION OF CODE

**Error Set:**

First Byte	Decimal	Hex	Error
#	0	0x00	NO ERROR
#	1-63	0x01-0x3A	RESERVED
#	64	0x40	DATA IS OUT OF RANGE
#	65	0x41	FREQUENCY IS DC LIMITED
#	66	0x42	PULSEWIDTH IS FREQUENCY LIMITED
#	67	0x43	DELAY IS FREQUENCY LIMITED
#	68	0x44	INVALID CONFIGURATION
#	69-111	0x45-0x6A	RESERVED
#	112	0x70	UNRECOGNIZED WORD
#	113	0x71	BAD STRING FORMAT
#	114	0x72	BAD DATA FORMAT
#	115	0x73	UNRECOGNIZED PARSE ERROR
#	116	0x74	BAD RESOLUTION
#	117-119	0x75-0x77	RESERVED
#	120	0x78	COMMAND NOT AVAILABLE
#	121	0x79	INTERNAL SYSTEM ERROR
#	122-255	0x80-0xFF	RESERVED

## Contact DEI

We want to hear from you! Directed Energy, Inc. provides a standard line of High Voltage Pulse Generators, Laser & Diode Drivers, and Test & Measurement Equipment. Additionally, DEI has the capability to provide custom modules and products to fit your volume or OEM application.

### **Web**

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### **Sales Customer Service & Support**

Phone: 970.493.1901

Fax: 970.493.1903

Email: [deiinfo@directedenergy.com](mailto:deiinfo@directedenergy.com)

### **Technical Customer Service & Support**

Email: [deitechsupport@directedenergy.com](mailto:deitechsupport@directedenergy.com)

## **Factory Service & Support**

This product has been designed to provide simple trouble-free use by qualified technical personnel, under normal operating conditions. In the event that you require technical support and/or product service our technical support staff is available to assist you. You can contact our team as noted previously. DEI's technical support is available as follows.

### ***Product Service***

- Warranty Service is provided per the terms and conditions of DEI's warranty described in the next section of this manual. To provide accurate and complete warranty service please contact our technical support team who will help you determine the nature of the problem and ensure that the unit must be returned to DEI. You will then be given an RMA number that our team will use to track your unit. Warranty service is free of repair or replacement charges.
- Non-Warranty Service is provided at our standard repair rate and is billed by the hour. There is a minimum evaluation charge for all non-warranty repairs.
- Shipping charges for both warranty and non-warranty repairs are the responsibility of the customer.

### ***Technical Support***

Technical support is available on our website or via email at [deitechsupport@directedenergy.com](mailto:deitechsupport@directedenergy.com).



## Warranty

Directed Energy, Inc. (DEI) warrants equipment it manufactures to be free from defects in materials and factory workmanship under conditions of normal use, and agrees to repair or replace any standard product that fails to perform as specified within one year after date of shipment to the original owner. OEM, modified and custom products are warranted, as stated above, for ninety (90) days from date of shipment to the original owner. This Warranty shall not apply to any product that has been:

- Repaired, worked on, or altered by persons unauthorized by DEI in such a manner as to impair, in DEI's sole judgment, the performance, stability, or reliability of the product;
- Subjected to misuse, negligence or accident; or
- Connected, installed, adjusted, or used otherwise than in accordance with instructions furnished by DEI.

DEI reserves the right to make any changes in the design or construction of its products at any time, without incurring any obligation to make any change whatever in units previously delivered.

DEI's sole obligation, and buyer's sole remedies, under this agreement shall be limited to a refund of the purchase price, or at DEI's sole discretion, to the repair or replacement of products in kind that prove, to DEI's satisfaction, to be defective, when returned to the DEI factory, transportation prepaid by the buyer, within the warranty period. DEI shall in no way be liable for damages consequential or incidental to defects in its products, for failure of delivery in whole or in part, for injuries resulting from its use, or for any other cause. Returns must be preauthorized and accompanied by a DEI return authorization number.

The foregoing states the entire warranty extended by DEI, and is given and accepted in lieu of 1) any and all other warranties, expressed or implied, including but not limited to the implied warranties of merchantability and fitness for any particular purpose and 2) any obligation, liability, right, claim or remedy in contract or tort.